THE HISTORY AND PRESENT STATUS OF GOLDEN TROUT IN MONTANA

by

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INTRODUCTION

Golden Trout, native to the Kern River drainage of the Sierra Nevada Mountains of California, is a fancy fish that captured the hearts of many a man. Two such men, Col. Sherman Stevens and his brother, transplanted 13 goldens from Mulkey Creek, a tributary of the South Fork of the Kern River, to Cottonwood Creek, California in 1876. The fish were carried in a coffee pot across the Divide, a distance of 4 miles, because the Stevens brothers were anxious that Cottonwood Creek be well stocked for their use near their sawmill site. In 1981, E. H. Edwards, a storekeeper at Lone Pine, California, and two friends planted some of these Cottonwood Creek fish in Cottonwood lakes, and by 1906 the lakes were described as being unusually well stocked with goldens (Ellis and Bryant 1920). In 1917, a spawning station was established at Cottonwood lakes (Pister 1964). This site became the source of golden trout eggs. From 1928 to 1938, eggs were shipped to the National Fish Hatchery in Bozeman (now the Fish Cultural Development Center). In 1939, an embargo on golden trout eggs was imposed by the California Legislature (McAfee 1966). One documented batch of 600 eggs supposedly was shipped to Montana in 1907 by the U. S. Bureau of Fisheries (Brown 1971) before establishment of the spawning stations at Cottonwood lakes.

Distribution records of the first golden trout delivered to Montana are vague and poorly documented. A search of state and federal hatchery records, literature correspondence, interviews and field examinations of expected golden trout habitats suggest the following lineage of the destination of golden trout in Montana.

Table A. Eggs received from Cottonwood lakes, a. 1907-1938

Year	No. Eggs	Rearing Station	No. & Destination of Fish
1907[1]	600	Bozeman N.F.H.	500 - Gallatin area
1928	50,000	Bozeman N.F.H.	9,000 - Gallatin N.F.[2]
1929	50,000	Bozeman N.F.H.	21,000 - Glacier N.F. 9,000 - Gallatin N.F. 2,000+- Wind River area, Wyoming, Cook Lake stock
1930	50,000	Bozeman N.F.H.	25,000 - Scheduled for Mission Mt. lakes Unkn. - Hidden, Lost Packer lakes, Bitterroot N.F.
1931	50,000	Bozeman N.F.H.	Unkn. - Upper & Lower Dutchman lakes

Table A. Eggs received from Cottonwood lakes, a. 1907-1938 (Cont.)

Year	No. Eggs	Rearing Station	No. & Destination of Fish
1932	56,025	Bozeman N.F.H.	5,200 - Hidden lakes #1 & #2 6,000 - Helena area Unkn. - Wind River Area, Wyoming
1935	25,000	Bozeman N.F.H.	Unkn. - Unknown
1938	100,000	Bozeman N.F.H.	16,200 - Gallatin N.F. 12,000 - Hidden lakes 8,000 - Golden Trout Lake 6,000 - Blue Danube 2,666 - Sears 2,666 - Emerald, Bitterroot N.F. lakes 2,668 - Lava 10,000 - Anaconda F.H., Lake of the Isle 3,000 - Sylvan Lake 12,000 - Lake Pinchot 5,000 - Jasper Lake
1939	Egg embargo		

[1]References: McCloud 1943; U. S. Bureau of Fisheries (Bozeman National Fish Hatchery records): correspondence and interviews.

[2]Fish designated to the Gallatin National Forest for distribution were in part responsible for golden trout once occupying Ramona, Avalanche, Papoose, Cataract, Falls and Blue Paradise lakes. One lot of 6,100 eggs was incubated in West Fork of Beaver Creek.

Table B. Eggs received from Surprise Lake, Wyoming - 1957, 1958, 1963 and 1977[1]

Year	No. Eggs	Rearing Station	No. & Destination of Fish
1957	34,887	Big Timber	2,000 - Fish, Wildlife & Parks Hdq. Pond at Bozeman 20 - Great Falls Fair - 1958

Table B. Eggs received from Surprise Lake, Wyoming - 1957, 1958, 1963 and 1977[1] (Cont.)

Year	No. Eggs	Rearing Station	No. & Destination of Fish
			400 - Creston N.F.H.
			Unkn. - Hamilton F.H.
1958[2]	62,000	Big Timber	2,560 - Sawtooth Lake - 1959
			1,600 - Hidden Lake #1 - 1959
			1,920 - Hidden Lake #3 - 1959
			1,600 - Hidden Lake #4 - 1959
			1,600 - Hidden Lake #8 - 1959
			10,000 - Kaufman (Falls Creek Lake)
			5,000 - West Boulder Lake
			31,000 - Jim lakes
			2,100 - Upper & Lower Sky lakes - 1960
			3,069 - Creston N.F.H.; part transferred to Hamilton F.H.; 510 to Herrig and 1,364 to Imagine lakes in 1959
1963	14,600	Big Timber	13,260 - Island, Crescent and Heart lakes
1977	11,200	Bozeman N.F.H.	2,600 - Duck Lake
			2,600 - Shrimp Lake
			4,500 - Fourmile Basin Creek Lake #4
			1,500 - Fourmile Basin Creek Lake #5

[1]State of Montana hatchery records - unpublished; some hatchery transfers are not listed.

[2]Some of the 1958 fish could have been from Hamilton stock; 35,055 eggs were received from Daniel, Wyoming on July 4, 1958.

Table C. Other Montana egg takes, 1953-1983

Year	Source Lake	Rearing Station	No. & Destination of Fish
1953	Blue Danube	Big Timber/ Hamilton	2-3,000 - Kootenai Lake

Table C. Other Montana egg takes, 1953-1983 (Cont.)

Year	Source Lake	Rearing Station	No. & Destination of Fish
1955	Sylvan	Big Timber	Unkn. - Hamilton F.H. (brood stock
			4,800 - Cairn Lake
			6,400 - Medicine Lake
			16,000 - Snowbank Lake (Fossil)
			4,800 - Dewey Lake
			1,600 - Big Park Lake
			6,400 - Lake at Falls
1956	Sylvan	Big Timber	10,300 - Lightning Lake
			1,052 - Lake of the Winds
			400 - Creston N.F.H.
			500 - Rhoda Lake
			1,328 - Louise Lake (Mary Lou)
1959	Sylvan	Big Timber	575 - Rhoda Lake
1964	Blue Danube	Big Timber	- eggs failed
1972	Sylvan	Big Timber	82 - Fish, Wildlife & Parks Hdq. pond, Bozeman
1980	Sylvan	Big Timber	1,300 - Cave Lake
1981[1]	Sylvan	Anaconda	5,600 - Big Butte Lake
			5,530 - Desolation Lake
			3,840 - Little Scat Lake
			3,360 - West Fishtail Creek Lake
			2,065 - Rock Tree Lake
			2,065 - Upper Whitney Lake
			1,920 - McKnight Lake
			1,920 - Upper McKnight Lake
			1,920 - Asteroid Lake
			1,440 - Dryad Lake
1982	Sylvan	Anaconda	6,500 - Desolation lakes
			6,500 - West Fishtail Creek lakes
1983	Sylvan	Anaconda	3,000 - Fourmile Basin Lake #4
			3,000 - Duck Lake

[1]All fish from 1981 egg take were planted in July 1982 as 4-inch fish in lakes in the Absaroka-Beartooth Wilderness.

Table D. Plants from Hamilton Fish Hatchery, 1960

Year	Rearing Station	Transfer Station	No. & Destination of Fish
1960	Hamilton	Libby	2,030 - Smith Lake Rearing Pond
1960	Hamilton	None	500 - Sock Lake 500 - Renshaw Lake
1960	Hamilton	Anaconda	2,500 - Fourmile Basin Lake #4 4,480 - Little Lake Creek lakes (2)
1960	Hamilton	None	Unkn. - Arrowhead Lake Unkn. - Duckhead Lake

Table E. Transfer by unauthorized persons

Lake Stocked	Source Lake	Approximate Year
Barrier	Lake Pinchot	1939

Table F. Downstream dispersement

Source Lake	Year Stocked in Source Lake	Recipient Lakes
Jasper	1938	Golden, Hidden
Lake Pinchot	1938	Flood Creek lakes (6)
Dewey	1955	Twin Outlets, Duggan, Big Park
Lake at Falls	1955	Rainbow, Rimrock
Hidden #1 & 2	1959	Hidden lakes #5, 6 & 7[1]

[1]This may have been an unauthorized transplant, since no evidence of 1959 plants appeared downstream.

The earliest dissemination of golden trout from the National Fish Hatchery in Bozeman was largely confined to the Gallatin National Forest. Much of this early stocking involved CCC and Forest crews; records were scarce. Many lakes were unnamed, others changed. Some unnamed lakes took on a name after the fish, e.g., Golden Trout and Golden lakes. It was the mid-1950's when fisheries employees in Montana resumed stocking golden trout. Populations in Sylvan and Surprise lakes supplied the eggs. A feeble attempt to establish a brood station at Hamilton was short-lived. The majority of the eggs were reared at Big Timber and stocked directly into the Beartooth area lakes, or were transferred to a hatchery on the west side of the Divide for subsequent dispersement.

The first recorded attempt at securing golden trout eggs was in 1953 at Blue Danube Lake in the Hilgards. A crew of Opheim, Mitchell, Spindler and Schurr stripped eggs, and subsequently 2,000-3,000 fish were raised at Big Timber and Hamilton hatcheries. The goldens were requested by a forest ranger for Kootenai Lake near Stevensville (Opheim 1953, pers. comm.).

In 1955, 1956 and 1959, eggs were collected at Sylvan Lake by combinations of the following: Nelson, Keller, Waples, Gaab, Taylor, Matthews, Eberle and Domrose. Some eggs collected by Higgins in 1964 from Blue Danube failed to develop. A small collection of eggs were taken in Sylvan Lake by Marcuson in 1972. These eggs were taken incidental to censusing the fishery. The small number of survivors (82) were stocked in the pond behind the Fish and Game headquarters in Bozeman. In 1980, approximately 2,000 eggs were again taken at Sylvan Lake by Peterson and Marcuson. Cave Lake in the Crazy Mountains was the recipient of 1,300 fish from this take. A collection of 488 adult goldens was obtained from Sylvan Lake in 1981 by Marcuson and crew. Peterson and Sholtz stripped 79,811 eggs from about 50% of the fish. These eggs were treated with erythromycin and delivered to Yellowstone River Trout Hatchery. They were later shipped to Washoe Springs Trout Hatchery in Anaconda. Approximately 30,000 fish were stocked in Beartooth mountain lakes in 1982 from this egg take.

Golden trout populations, once fairly prevalent in approximately 50 lakes in Montana now reside in 14 habitats. The demise of golden trout populations were of four causes: 1) inability to sustain; 2) winterkill in marginal habitats; 3) hybridization with other spring spawners and 4) inability to compete with brook trout.

Rainbow and cutthroat trout plants directly into golden trout waters or in lakes upstream soon hybridized and the genetic integrity of the pure golden trout was lost. Because of the golden trout's elusiveness to observation, hook and line and sometimes netting, fish managers or unauthorized transplanters assumed barrenness. One objective of this paper is to prevent further hybridization by describing the status and whereabouts of the existing golden trout populations.

METHODS

Water temperatures were collected with three 30-day recording thermographs at Sylvan and Lightning lakes during 1973 and 1975. Surface to bottom water temperatures were measured over deep portions of these lakes with a thermistor and probe. Instantaneous temperatures were read with a pocket thermometer in association with all investigative actions.

Substrate composition of artificial and natural spawning sites was taken with the aid of a 2-pound coffee tin. Grain-size analysis followed the procedures of Welch (1948). A Price-type current meter and a staff gauge was employed in the outlets of Sylvan and Lightning lakes, and flows were converted to cubic feet per second. Redd sites were measured to the nearest inch.

Fish were collected in nylon 5x125-foot gill nets (graduated mesh 3/4 to 2 inches square) set overnight in each lake. All representative samples were photographed and coloration was noted and sketched. Lengths, weights, sex, fat content and body condition were recorded on each fish. Stomachs were removed, sorted to length groups and preserved in formalin. Contents of stomachs were sorted, counted and weighed. Only contents anterior to the pyloric caece were considered. Food types were cataloged in relation to where it was consumed: terrestrial, water column or benthic zones.

Scales and otoliths were removed from each fish for aging. Eggs were counted in each morbid female of various size groups.

Protocol for collection of fish health inspections followed the format of the U. S. Department of the Interior, Fish and Wildlife Service, Fish Disease Control Center. Attempts were made to have at least a 30-fish sample of each feral population of golden trout. Samples collected included fecal material in 10% formalin, fecal smears trypticase soy agar, (TSA) cultures, saline preserved kidney/spleen samples and gill arches in 10% formalin. Genetic samples involved collecting one eye, a slice of kidney and muscle tissue from each fish. Genetic variation was determined by Steve Phelps, Population Genetics Laboratory, University of Montana, using horizontal starch gel electrophoresis according to method of Utter, Hodgins and Allendorf (1974).

FINDINGS

Locations

As of 1981, the State of Montana had 17 lakes harboring golden trout (Table 1). Because of the close proximity of certain waters and interchange of fish between waters as in Lightning and Little Lightning and three Hidden lakes in the Gallatin, only 14 real populations existed in 1981.

Table 1. Golden trout waters in Montana, 1981

Lake	Mountain Range	FWP[1] Region	FWP[2] Code No.	National Forest[3]	Location	Wilderness Areas[4]
Lightning	Beartooth	5	22-8372	08	T6S, R13E, S. 2D	A-B
Little Lightning	Beartooth	5	22-8372	08	T6S, R13E, S. 2DA	A-B
Sylvan	Beartooth	5	22-9394	08	T7S, R17E, S. 26	A-B
Cave	Crazy	5	22-7449	11	T4N, R11E, S. 26	
Blue Danube	Hilgards	3	13-6960	11	T11S, R2E, S. 14AD	
Sawtooth	Pioneers	3	01-9460	02	T5S, R12E, S. 1B	
Heart	Missions	1	07-6660	10	T19N, R18W, S. 26A	MM
Island	Missions	1	07-6880	10	T19N, R18W, S. 26BD	MM
Crescent	Missions	1	07-5880	10	T19N, R18W, S. 25B	MM
Hidden #2	Gallatin	3	09-8399	11	T6S, R4E, S. 36DA	
Hidden #5	Gallatin	3	09-8402	11	T6S, R5E, S. 31CCB	
Hidden #6	Gallatin	3	09-8403	11	T6S, R5E, S. 31CCA	
Hidden #7	Gallatin	3	09-8404	11	T6S, R5E, S. 31CB	
Golden Trout	Gallatin	3	09-8094	11	T7S, R5E, S. 17BA	
Fourmile Basin #4	Anaconda-Pintlar	2	06-7867	09	T4N, R13W, S. 20AA	

Table 1. Golden trout waters in Montana, 1981 (cont.)

Lake	Mountain Range	FWP[1] Region	FWP[2] Code No.	National Forest[3]	Location	Wilderness Areas[4]
Duck	Anaconda-Pintlar	2	06-7680	09	T4N, R13W, S. 21CCA	
Shrimp	Anaconda-Pintlar	2	06-9180	09	T4N, R13W, S. 29A	

[1] = Kalispell, 2 = Missoula, 3 = Bozeman, 5 = Billings.

[2]Drainages are designated by first two characters: 01 = Beaverhead, 06 = Clarks Fork, 07 = Flathead, 09 = Gallatin, 13 = Madison, 22 = Yellowstone.

[3]National Forests codes: 02 = Beaverhead, 08 = Custer, 09 = Deer Lodge, 10 = Flathead, 11 = Gallatin.

[4] AB = Absaroka-Beartooth, MM = Mission Mountains.

Golden trout populations in Montana were found only in lakes; no stream populations were found. All waters were accessible by maintained Forest trails, except Lightning and Cave lakes. Distances from trail heads to lake shores ranged from 2 to 8 miles.

Stocking Histories

The existing 14 stocks of golden trout were the result of egg shipments to Montana between 1928 and 1938 from collecting facilities at Cottonwood lakes, California; Surprise Lake, Wyoming and transplants from Sylvan Lake (Table 2).

Catch Data, 1981

During August 1981, 19 experimental nets were set in 13 alpine lakes where golden trout populations were anticipated. Golden trout were captured in all but two lakes. Two experimental nets set in Cave Lake were folded to increase the catchable surface area, but no fish were captured or observed. The lack of catch was assumed a result of small yearling fish, inadequate mesh size and small numbers of fish (stocked at 84/acre in 1980). An overnight gill net set August 8, 1982 captured five 2-year-old goldens.

It was also known to this investigator that brook trout coexisted with golden trout in Fourmile Basin Lake #3 near Anaconda. An experimental net set overnight in this lake captured only brook trout.

Another experimental net was set in Hidden Lake in the Beartooth Mountain Range. The last sampling of this water in 1976 produced equal numbers of Age Class II golden and cutthroat trout (Marcuson 1980). The net set in 1981 captured only cutthroat trout. No golden trout were observed and goldens are assumed extinct in Hidden Lake.

Examination of hatchery records at Anaconda revealed golden trout were stocked in two of eight lakes in Fourmile Creek Basin in 1977. Evidence of these fish appeared in Fourmile Basin Lake #4; none were captured or observed in Fourmile Basin Lake #5. Records also showed Duck and Shrimp lakes in nearby Twin Creek drainage were stocked at the same time. No nets were set in these lakes, and again it is assumed that goldens occupied these waters in 1981; however, no reproduction was expected (Vashro, pers. comm.).

Island Lake in Mission Mountains yielded the largest overnight catch of golden trout in a gill net. Numerous fish were observed jumping and swimming shoal areas. Individual fish were mostly small, less than .25 pounds. The population density appeared greater than optimum for available food and space. Reproduction was obvious and mortality from angling appears insignificant.

Table 2. An artery of the lineage of golden trout in Montana, 1981

Lake	Original Source	Year Stocked	2nd Source and Year	3rd Source and Year
Lightning	Sylvan Lake	1956	None	None
Sylvan	Cottonwood Lake, California	1938	None	None
Cave	Sylvan Lake	1980	None	None
Blue Danube	Cottonwood Lake, California	1938	None	None
Sawtooth	Surprise Lake, Wyoming	1959[1]	None	None
Island, Heart & Crescent	Surprise Lake, Wyoming	1963	None	None
Hidden #2	Cottonwood Lake, California	1932	Cottonwood Lake, 1938	Surprise 1959[2]
Hidden #5, 6 & 7	Cottonwood Lake, California	1938	None	None
Golden Trout	Cottonwood Lake California	1938	None	None
Fourmile Basin	Surprise Lake, Wyoming	1960	Surprise 1977	None
Duck	Surprise Lake, Wyoming	1977	None	None

Table 2. An artery of the lineage of golden trout in Montana, 1981 (cont.)

Lake	Original Source	Year Stocked	2nd Source and Year	3rd Source and Year
Shrimp	Surprise Lake, Wyoming	1977	None	None

[1]Planted as 6-inch fish from 1958 eggs from Surprise Lake, Wyoming.

[2]Stocked in Hidden Lake #1 just upstream from Hidden Lake #2 as 6-inch fish from 1958 eggs.

Heart Lake immediately downstream from Island Lake yielded only one 4-year-old trout. No other fish were observed from shore or while snorkeling. Based on the excellent condition of this one fish, its size at Age IV and the high level of available food, it appeared Heart Lake was at an extreme low-density level.

Crescent Lake produced an overnight catch of 11 golden trout, all very small fish. Others were observed jumping and swimming shoal areas. No sexually mature females were captured.

Sawtooth Lake in the Pioneer Mountain Range produced a well-balanced structure of numerous, well-composed fish. Reproduction was evident with juveniles aggregated around redd sites in the inlet. Wipperman witnessed a similar structure in 1964.

Fourmile Basin Lake #4 appeared to have few fish. Two fish were observed and two fish were captured. Both fish were Age IV and averaged 1 pound. Gillnetting in 1962 produced 21 golden trout between 7.3 and 8.6 inches (Marcoux 1973). All fish were Age II from a 1960 plant. In 1981 fingerlings were observed in the outlet. However, the exit of this stream at the lake created a barrier to juvenile recruitment back to the lake. Many juveniles were trapped in small isolated pools.

Little Lightning Lake always produced numerous small 2 and 3-year-old fish (Marcuson 1980). The largest fish captured in Little Lightning Lake was a 16.3-inch, 1.56-pound female.

Eleven fish netted in Hidden Lake #2 were of three size groups (8.5, 10.8 and 14.6 inches), indicating at least partial reproductive success. This shallow lake was sparsely populated with golden trout. One fish was observed in the shallow inlet stream 150 feet upstream from the lake's confluence. Fish were full of Gammarus lactustris and were in good physical condition.

Numerous small golden trout were observed and captured by hook and line in the shallow, pond-like environments of Hidden lakes #5, 6 and 7. Gaffney (pers. comm.) reported observing numerous, small golden trout in these lakes in 1958. The 1981 experimental net set in Hidden Lake #5 captured seven golden trout, averaging 7.8 inches and 0.17 pounds. These brightly colored fish spawn in the small stream between Hidden lakes #5, 6 and 7; access between lakes was unobstructed. These fish appeared totally different in coloration from those fish in Hidden Lake #2 upstream. The outflow of Hidden Lake #2 had 350 feet of gradient with falls and appeared suicidal to fish moving downstream. The physical features of the Hidden lakes make for three separate ecological entities: lakes #1 and 2; lakes #5, 6 and 7 and lakes #3, 4 and 8. The latter group had occasional golden trout; none were observed in 1981. They were last stocked in 1959 with 6-inch fish.

Golden trout were prevalent in Golden Trout Lake in the Gallatin drainage. Numerous small fish were observed. Camping sites and shoreline abuse suggested heavy fishing pressure. Eggs

were excavated from redds in a small reach of inlet near the lake and in a small meadow 120 feet in distance and at an elevation of 80 feet above Golden Trout Lake. No juveniles were found. In spite of the eggs upstream, the inlet appeared to have much too much gradient for fish passage. No fish were found in the upstream ponds. Unauthorized transplants may occur occasionally in this area. The outlet appeared the primary spawning site; juveniles were common in pools and aggregated around the outlet-lake margin.

Of all lakes sampled, Blue Danube appeared to have the lowest population density. Only one fish was captured, none were observed and two outfitters complained of no fish. Marcoux (pers. comm.) surveyed Blue Danube in 1975 and found a good population ranging from 6.5 to 18 inches. Previous spawning success was restricted to the outlet which when observed in 1981 provided little flow and a silted substrate. No fish were observed downstream or in a meadow lake 1/4 mile down drainage.

A total of 488 golden trout were collected in 2 1/2 days for obtaining 79,811 eggs in early July 1981 at Sylvan Lake. The female parents of the eggs averaged 10.5 inches; males were 10.0 inches. Two gill nets pulled September 1, 1981 produced 40 fish, averaging 9.0 inches, .32 pounds. This lake consistently produced numerous fish, most less than 13 inches in length.

Appearance and Coloration

The lack of homogenous coloration, spotting and overall appearance of various golden trout populations and even individual fish within a population led scientists to classification disagreements. From early on, golden trout were classified Salmo iridius (Henshaw 1875), S. mykiss aquabonita (Jordan and Henshaw 1878), S. whitei (Marcuson 1980) and S. gilberti (Vore 1928). The two latest studies, Schreck and Behnke (1971) and Gold and Gall (1980), concur on the present acceptable subspecies S. aquabonita aquabonita. The other subspecies, S. a. gilberti, still has some confusion regarding classonomic integrity.

Golden trout in Montana all have their roots from S. a. aquabonita in Cottonwood lakes, California; however, two distinct appearing types of goldens were apparent. Those fish with a lineage via "Surprise Lake," Wyoming stocked between 1960 and 1977 had an appearance and coloration different from those which were direct plants from Cottonwood lakes. The latter group was termed "typical" (Table 3).

The "typical" golden trout described by Evermann (1905) and McAfee (1966) had the following coloration and spotting characteristics:

1. Coloration - Bright, cherry-red belly from throat to anal fin; predominately deep olive-green back; metallic, lemon-yellow sides; rosy lateral band; one series of 10-12 large,

Table 3. Summary of catch of golden trout in experimental nets, 1981

Lake	Dates Sampled	Number Captured/ Net	Range L	Range Wt	Average L	Average Wt	Coloration[1]	Ratio M:F
Heart	8/10-8/11/81	1	-	-	12.7	0.87	Surprise Lake	- -
Crescent	8/10-8/11/81	11	5.5-9.4	.08-.38	6.6	.13	Surprise Lake	1:1
Island	8/10-8/11/81	88	5.4-12.6	.12-.73	8.1	.23	Surprise Lake	1:1
Sawtooth	8/19 8/20/81	48	6.8-15.5	.01-1.38	10.7	.51	Surprise Lake	1:1
Fourmile #4	8/21-8/22/81	2	13.0-14.3	.93-1.07	13.7	1.00	Surprise Lake	1:1
Little Lightning	8/20-8/21/81	42	6.0-16.3	.09-1.56	7.7	.23	Typical	1:1
Hidden #5	8/27-8/28/81	7	6.0-9.0	.08-.22	7.8	.17	Surprise Lake	2.5:1
Hidden #2	8/27-8/28/81	11	8.5-15.4	.31-1.78	13.3	1.22	Typcial	1:1.2
Golden Trout	8/28 8/29/81	30	5.6-9.6	.06-.26	7.8	.17	Typical	1:1.7
Blue Danube	8/29-8/30/81	1	-	-	9.4	.26	Typical	-

Table 3. Summary of catch of golden trout in experimental nets, 1981 (cont.)

Lake	Dates Sampled	Number Captured/ Net	Range L	Range Wt	Average L	Average Wt	Coloration[1]	Ratio M:F
Sylvan	9/1-9/2/81	20	6.0-11.6	.12-.56	9.0	.32	Typical	1.3:1

[1]Typical = classic golden trout as described by Evermann (1905); Surprise Lake = a lighter, silvery, robust bodied fish (see text).

prominent parr marks silvery-gray in color; white tips on anal and ventral fins.

2. Spotting - Large spots, few in number, concentrated in caudal area, few below lateral line; none or very few on body anterior to dorsal fin; dorsal and caudal fin heavily spotted.

The "Surprise Lake" golden trout tended to have the following characteristics:

1. Coloration - Silvery or lighter pigmented; less vivid olive-green back; anal fin with less orange coloration; rosy lateral band often less vivid than on "typical" type; 10-12 large, silvery-gray parr marks which do not stand out as much as on the "typical"; white tips on anal and ventral fins.

2. Spotting - Same as on "typical" golden trout except for more spotting anterior to dorsal fin.

3. Body - Usually more robust, less slender than "typical" golden trout.

To complicate further, there were variations in colorations of some individual golden trout in specific waters. Similar to California habitats (Pister, pers. comm.) some individuals in the "typical" class became more silvery and somewhat similar to the "Surprise Lake" fish, especially in large lakes. Lighter color variations were usually females scrutinized well after the spawning season. Large lakes also had large males and females without prominent parr markings. Often large males in large lakes were crimson from the eye to the anal fin with this vivid color merging into the olive-green colored back. The newest State of Montana record (1981) was a male with this dominant red coloration.

Age and Growth

The most pronounced differences in growth between populations of golden trout were among Age IV and older fish (Table 4). A mean difference of 4.8, 4.3 and 3.9 inches existed for the Ages IV, V and VII fish, respectively. The smallest golden trout resided in the small pond-like lakes in the Hidden Lake chain #5, 6 and 7. Golden Trout Lake also contained small fish. Island Lake appeared overpopulated with somewhat stunted fish. The population structure in Island Lake appeared similar to that of Cottonwood Lake #3 in California (Curtis 1934).

Sylvan and Little Lightning lakes are not noted for large fish; however, populations were usually represented with a complement of age groups. Growth inhibition in Sylvan Lake appeared food related, while Little Lightning Lake acted as a nursery for Lightning Lake with some older residents. Ninety-five percent of the fish were 3 years old and younger. Growth rates in Cottonwood Lake #4 in California resemble that in Sylvan Lake.

Table 4. Mean age and growth at last annulus of golden trout in Montana. Sample size in parentheses

Lake[1]	Age Groups I	II	III	IV	V	VI	VII	VIII+
Heart				12.7(1)				
Crescent		6.9(9)	9.0(2)					
Island		6.4(39)	7.7(2)	8.9(27)	10.3(14)	11.7(6)		
Sawtooth		6.9(2)	8.7(16)	10.9(16)	14.1(3)	15.5(1)		
Fourmile Basin #4				13.7(2)				
Lightning		7.2(22)	9.1(14)	11.8(8)	14.3(6)	15.6(5)	17.1(4)	18.5(2)
Little Lightning	4.6(53)	7.2(41)	8.4(35)	11.0(3)	13.3(2)	14.5(1)	16.3(1)	
Hidden #5		6.4(2)						
Hidden #2			8.5(1)	10.8(2)	14.6(8)			
Golden Trout		6.3(7)	8.0(12)	8.9(10)				
Blue Danube				9.4(1)				
Sylvan	4.7(20)	7.2(82)	9.0(162)	10.3(96)	11.1(23)	13.0(5)		
Cave		6.2(5)						

Table 4. Mean age and growth at last annulus of golden trout in Montana. Sample size in parentheses (cont.)

Lake[1]	Age Groups I	II	III	IV	V	VI	VII	VIII+
Montana Mean	4.7	6.7	8.7	11.1	13.5	14.7	16.7	18.5
[2]Cottonwood Lake #3 California	2.0	5.0	7.4	8.2	8.7			
Cottonwood Lake #4 California	1.6	5.7	9.0	11.2	11.4			

[1]Sylvan and Lightning lakes include an average of 1981 and previous data.

[2]See Curtis 1934.

The largest golden trout resided in Lightning Lake, where immature fish were rarely captured. Hidden Lake #2 had indications of a low density, good growth situation. Large, esthetic fish were common to Sawtooth and Fourmile Basin Creek Lake #4 where food organisms were abundant.

Numerous collecting efforts of golden trout in Lightning and Sylvan lakes suggested hardships were typical during winter months. Fish were of slighter body, weights registered lighter and condition factors averaged five digits lower in the early spring. Fish, however, filled out markedly by spawning season in early July. Larger females had fewer and smaller scales than smaller fish. Large males rarely had removable scales, just heavy pigmented skin.

Golden trout in Sylvan and Lightning lakes enter their first winter at less than 1 month of age at a mean size of 1.2 inches. No scales were formed the first winter. Juveniles grew during the winter and were between 3.0 and 4.0 inches at ice breakup. By Age I, they ranged from 4.3 to 5.5 inches.

In the other populations of golden trout in Montana, juveniles observed in late August 1981 were larger than those living at the higher altitudes of Sylvan and Lightning lakes. However, at Age Group II, most of these fish averaged smaller than goldens in Lightning and Sylvan lakes.

The oldest goldens examined in Montana were a population of now extinct, known-age, 14-year-old fish in West Boulder Lake in the Absaroka Mountain Range. They ranged from 14.3 to 18.2 inches and were sexually ripe during the spring of their 14th year (Marcuson 1976).

The State of Montana record for golden trout captured by an angler (in 1981) was 20.5 inches, 3.14 pounds. This fish was one of a few left in Lake at Falls in the Beartooth Mountains. The largest unofficial record was a fish estimated at 14 pounds. This large fish was trapped, stripped of eggs and released in Lightning Lake in 1975 by the author.

Condition factors ranged from a low of 31.3 for a one-fish sample in Blue Danube to 52.1 for goldens from Lightning Lake. Condition factors ($C = \frac{100,000\ W}{L^3}$) for each lake averaged as follows:

Blue Danube	31.3	Island	43.3
Golden Trout	35.8	Sylvan	43.9
Hidden #5, 6 & 7	35.8	Crescent	45.2
Fourmile Basin #4	38.9	Little Lightning	50.4
Sawtooth	41.6	Hidden #2	51.9
Heart	42.5	Lightning	52.1
		Cave	54.5

The mean condition factor in Cottonwood lakes was 38.8 (Curtis 1934).

Reproduction

Ice covered about half of Sylvan and Lightning lakes' surface when Age III and older fish started assembling near warmer outlet waters. In Sylvan Lake this occurred June 20, 1981; June 27, 1973 and July 12, 1975. Spawning began 15± days later in Lightning Lake with less exposure and 187 additional feet of elevation than Sylvan Lake.

Fish moved into outlet traps and shoal area near the outlet when water temperatures were near 40° F and began spawning in temperatures from 44 to 58° F. No eggs could be artifically taken at temperatures less than 44° F. The peak spawning activity in Sylvan Lake occurred July 6, 1981; July 9, 1973 and July 20, 1975 when temperatures ranged between 48 and 54° F.

During 3 years of studying reproductive activities of golden trout, the 3 and 4-year-old fish were the most numerous age groups in the spawning run (Table 5) in Sylvan Lake. Age II fish were predominately precocious males. A few 2-year-old females yielded 50 to 150 eggs. Ages III and IV females, usually 9-11 inches in length, produced 350-700 eggs. One 19-inch female had 1,750 eggs (Fig. 1).

Redds were generally small, often occupying small gravel deposits between rocks. A typical redd covered a 3x6-inch area, 3-4 inches deep and from 8-12.5 inches under water. Redd sites in pea gravel along lake shoals were mostly high and dry before emergence.

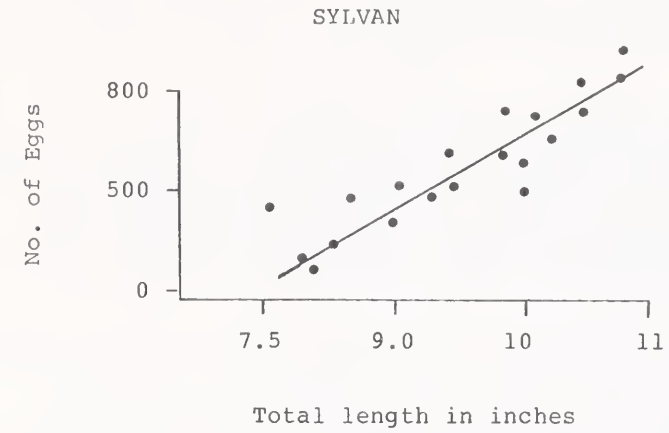
The spawning substrate at each successful artifical redd site as well as numerous selected natural redds was composed of 2-inch and smaller rock. All successful hatching was in material with less than 1% fines and with less than 10% of the material smaller than .5 mm.

Incubation period ranged from 46-50 days at a mean temperature of 52° F in Sylvan Lake. In Lightning Lake, emergence took 52 days at a mean temperature of 46° F. Fish were 1.2 inches when their yolk sacs were absorbed in September. Eggs incubated at 52° F at the Yellowstone River Trout Hatchery took 31 days to hatch. Hatching time was 28 days at 46° F at Daniel Hatchery, Wyoming (Hudelson, pers. comm.) and 24 days at 60° F at the Mount Whitney Hatchery in California (Toth, pers. comm.).

Examination of other Montana waters with golden trout revealed a similar preference for outlets as primary spawning sites. Evidence of some inlet spawning was apparent at Hidden Lake #2 which had a lake upstream; some at Golden Trout Lake, also with lotic waters upstream, and Sawtooth Lake. No evidence of outlet utilization by goldens was apparent at Sawtooth Lake. Water temperatures < = 40° F during the physiological stage goldens were ready to spawn apparently determined whether a population became self-sufficient. Most alpine lakes, unless part of a chain or a wide spot in the stream, did not have one

Table 5. Composition of spawners trapped in the outlets of Sylvan and Lightning lakes

Spawning Run			Fish Statistics		Percent Composition of age Groups						
Start Date	Peak	Last Fish	Avg. L M	Avg. L F	Sex Ratio M:F	II	III	IV	V	VI	Older
				SYLVAN							
7/3/73	7/9/73	7/21/73	9.9	9.7	1:2.1	8	38	43	6	3	2
7/8/75	7/16/75	8/1/75	9.7	9.6	1:2.1	5	40	47	5	2	1
6/20/81	7/6/81	7/18/81	10.0	10.5	1:2	3	36	51	6	2	2
				LIGHTNING							
7/15/75	7/18/75	8/4/75	11.5	10.7	1:1.2	8	57	20	6	4	5



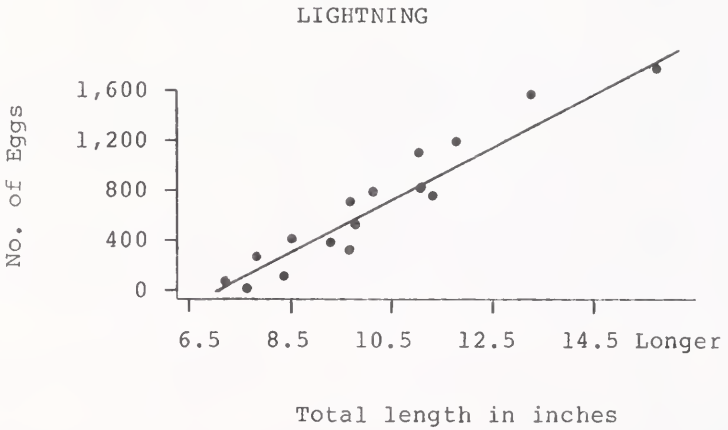


Fig. 1 Egg complements of golden trout in Sylvan and Lightning lakes.

consolidated inlet. Rather, they had numerous, ephemeral runoffs from surrounding snow and ice fields.

Food Habits

Lakes harboring golden trout all had their individuality regarding consumable organisms available to fish diets. Specific studies on six Absaroka-Beartooth lakes revealed golden trout were not totally opportunistic where menu choices were available. Golden trout populations in Montana were found in three types of lake habitats: 1) eutrophic, pond-like lakes; 2) small, somewhat shallow oligotrophic lakes and 3) large oligotrophic lakes (Table 6).

Those fisheries in the eutrophic class were more opportunistic feeders, utilizing numerous items. The mainstay in these habitats appeared to be mostly dipterans and Gammarus.

With the exception of Sylvan Lake, goldens occupying small oligotrophic lakes were usually part of a string or chain of lakes. Populations of fish were often dependent on reproduction upstream. The occupants of small, oligotrophic lakes are small to medium sized fish with an occasional larger 1 1/2 pounder. These lakes supported less invertebrate diversity than eutrophic lakes. Food organisms were taken from the benthic to surface zone, depending on the season. Dipteran pupa taken in the water column represented the overwhelming food consumed.

Large oligotrophic lakes usually supported larger golden trout. Diversity of invertebrates was no greater than that found in small oligotrophic lakes, but the quantity of organisms was higher. Typical zooplankton density was 450-900 per cubic meter of water in large lakes compared to 50-200/m^3 in small oligotrophic lakes. Zooplankton of the large varieties (+2 mm) were usually absent in smaller, shallower lakes. Of those lakes listed in Table 6, only Blue Danube failed to produce large fish in 1981. Benthic organisms were preferred nourishment in large oligotrophic lakes.

Table 6. Class of lake habitats with golden trout in Montana

Small Eutrophic	Small Oligotrophic[1]	Large Oligotrophic
Hidden #5, 6, 7	Little Lightning	Lightning
Golden Trout	Sylvan	Sawtooth
	Hidden #2	Fourmile Basin #4
	Island	Blue Danube
	Crescent	Cave
	Heart	

[1]Sometimes referred to as Mesotrophic.

An accumulated sample of 419 stomachs were collected seasonally from six Absaroka-Beartooth lakes between 1972 and 1981 and another 401 stomach samples in Sylvan and Lightning lakes. Differences were more evident among diets of fish in small lakes than those larger fish typical of large lakes (Table 7).

Larger fish in large lakes fed heavily on benthic organisms, larva forms of Diptera, Plecoptera, Tricoptera and Ephemoptera. Water column foods were next most popular; Diptera pupa and, when available, Gammarus dominated the choice. Zooplankton were found incidental to other foods in only six fish in larger lakes. During, before and after spawning, some surface feeding was observed. The total weight and numbers of terrestrial organisms in golden trout diets was usually small, even though the frequency of terrestrial-originated foods was common, especially during the spring.

Most of the food consumed in small oligotrophic lakes originated in the water column followed by the benthic and lastly from the terrestrial environment. Dipteran pupa again were the most heavily utilized feed. During winter, larval Dipterans from the benthic zone dominated the menu. Cladoceran zooplankters were utilized under ice conditions by some of Sylvan lakes' younger golden trout, a food source rarely utilized in the lakes studied. The dominant terrestrial food organisms in both small and large oligotrophic lakes were flying ants.

Of 820 stomachs analyzed, there was never an incidence of fish or fish eggs. This held true throughout the spawning and emergence periods. Golden trout occupying Lightning Lake were rarely seen after spawning season. This disappearing act was in harmony with resumption of benthic feeding activity, often in the deepest water near the outlet.

Competition

The demise of Montana's 50 plus populations of golden trout were largely due to introductions of other spring spawning species of fish. Hybridization was commonplace; species were replaced. Seventeen lakes in Montana are still known for these colorful crosses (Table 8).

Golden trout are eventually eliminated when cohabiting a lake with brook trout. Golden trout in Fourmile Basin Lake #3 never sustained in the presence of brook trout. One golden trout and 42 brook trout were gillnetted in 1962 (Whitney and Domrose 1964); 2 goldens, 40 brook trout were netted in 1973 (Marcoux 1973) and no goldens were found and 32 brook trout netted in 1981. Density of trout in Fourmile #3 was dependent on an occasional escape from Fourmile #4 upstream, escaping predation and finding food in an already crowded environment of brook trout.

Table 7. Summary of diets of golden trout in six lakes in the Absaroka-Beartooth Mountains, Montana

	No. of Stomachs	Frequency of Occurrence[1]			
		Terrestrial	Water Column	Benthic	Misc.
+8 inches	362	182	233	195	241
-8 inches	60	6	32	31	37
Spring	62	29	42	38	31
Summer	305	120	196	151	206
Fall	48	38	25	34	38
Winter	4	0	3	3	3
Large lakes	63	37	39	48	37
Small lakes	356	151	227	178	244

	No. of Stomachs	Number Organisms Consumed			
		Terrestrial	Water Column	Benthic	Misc.
+8 inches	347	4,049	81,125	17,890	-
-8 inches	60	384	10,585	3,499	-
Spring	47	222	1,021	1,049	-
Summer	305	3,069	89,232	14,627	-
Fall	48	1,176	793	6,583	-
Winter	4	0	68	29	-
Large lakes	63	355	811	6,583	-
Small lakes	341	4,078	90,899	14,499	-

Table 7. Summary of diets of golden trout in six lakes in the Absaroka-Beartooth Mountains, Montana (cont.)

	No. of Stomachs	Biomass (Grams) of Organisms Consumed			
		Terrestrial	Water Column	Benthic	Misc.
+8 inches	362	38.50	176.58	92.18	65.59
-8 inches	60	.21	7.33	6.21	7.68
Spring	62	3.81	11.66	14.79	10.23
Summer	305	18.28	137.10	42.94	40.93
Fall	48	16.09	8.15	36.58	12.12
Winter	4	0	.05	.06	.05
Large lakes	63	8.53	38.45	41.87	7.46
Small lakes	356	30.25	14.547	56.49	65.82

[1]Number of stomachs containing organisms in the four categories.

Table 8. Lakes in Montana with golden trout hybrids

Lake	Hybrid	Mountain Range
Lake of the Isle	Gt x Ct x Rb	Anaconda-Pintlar
Twin Outlets	Gt x Ct	Beartooth
Big Park	Gt x Ct	Beartooth
Lake at Falls	Gt x Ct	Beartooth
Duggan	Gt x Ct	Beartooth
Rainbow	Gt x Rb	Beartooth
Rimrock	Gt x Rb	Beartooth
Barrier	Gt x Rb	Beartooth
Bill	Gt x Rb x Ct	Beartooth
Mini	Gt x Rb x Ct	Beartooth
Cimmerian	Gt x Rb x Ct	Beartooth
Lake Surrender	Gt x Rb x Ct	Beartooth
Raven	Gt x Rb x Ct	Beartooth
Dreary	Gt x Rb x Ct	Beartooth
Lake Pinchot	Gt x Rb	Beartooth
Blue Paradise	Gt x Rb	Madison
Cataract	Gt x Rb	Madison

Fish Health (Jim Peterson, pers. comm.)

No unusual incidences of physical abnormalities were observed among golden trout in Montana. All were free of visible signs of disease symptoms. No viral pathogens were isolated; however, T.S.A. cultures revealed a general prevalence (six of nine populations of Yersinia ruckeri, serotype 2. Samples from Sylvan Lake were found to contain Y. ruckeri, both serotypes 1 and 2. No type 1 was isolated from the other populations sampled, and no Y. ruckeri of either serotype was found in samples from Fourmile Basin #4, Blue Danube or Lower Lightning Lake (Table 9). Y. ruckeri is the bacterial pathogen that causes Enteric Redmouth (ERM), a disease which often results in heavy mortality, especially when introduced into a crowded situation such as a fish hatchery. It is important to remember that ERM was not observed in these fish, but the causative organism (Y. ruckeri) was, and so the potential for disease exists. Y. ruckeri serotype 2 is much less pathogenic to trout than serotype 1 and "...probably pose no more threat than many genera of ubiquitous bacteria in the aquatic environment..." (Janeke, pers. comm.).

The first samples of 18 goldens from Sylvan Lake were live-captured in gill nets, held from 5 to 48 hours in crowded live-cars and artificially spawned. Fifteen of 18 samples were found to contain Y. ruckeri (serotypes 1 from 3 fish, serotype 2 from 11 fish, and serotypes 1 and 2 from 1 fish). A second sample 63 days later found Y. ruckeri in 10 of 30 fish sampled (nine serotype 2, one serotype 1). These goldens were stressed by gillnetting, but not to the degree of the first sample.

The health samples collected from spawning goldens at the time eggs were collected in 1981 were routine. No evidence of a pathogen was apparent and there was no reason to suspect that Y. ruckeri was present. Another precaution taken at that time was to water-harden all eggs collected in a 3 mg/L solution of erythromycin (Abbot Labs). Erythromycin is commonly used in Montana when collecting eggs from wild sources to help eliminate the possible spread of bacterial fish pathogens. Y. ruckeri is transmitted fish to fish via the water and there is no conclusive proof of egg transmissions (Klontz et al. 1976). However, because this precaution was taken, we are hopeful that any possibility of transmission of this pathogen from Sylvan Lake was interrupted. Eggs collected in 1980 for Cave Lake were also water hardened in erythromycin and the fish were found negative for Y. ruckeri.

The eggs collected at Sylvan Lake in 1981 were hatched and reared at the Washoe Park Trout Hatchery at Anaconda. These goldens suffered from parasitic infections of Hexamita, Costia and Cyrodactylus incurred from the hatchery water supply. Some mortality was experienced, but treatment for the parasites controlled the situation. These fish were sampled for Y. ruckeri when they were 2,100/pound and again when 150/pound. No Y. ruckeri was found.

Table 9. Incidence of *Y. ruckeri* in golden trout from Montana

Sample Site	Date	Sample Size	Fish Numbers with Y. ruckeri		
			Serotype 1	Serotype 2	Serotypes 1 & 2
Sylvan	7/1/81	18	3	11	1
Sylvan	9/2/81	30	1	9	0
Heart, Island & Crescent	8/11/81	60	0	15	0
Hidden #2 & 5	8/28/81	18	0	3	0
Sawtooth	8/19/81	30	0	3	0
Fourmile Basin #4	8/22/81	7	0	0	0
Lower Lightning	8/21/81	30	0	0	0
Golden Trout	8/29/81	30	0	3	0
Blue Danube	8/30/81	1	0	0	0
Cave	8/8/82	5	0	0	0

[1]A sample of five brook trout in Fourmile Basin Creek Lake #3 had one serotype 2 fish.

Other states have tried rearing golden trout under hatchery conditions. Attempts to hold brood stocks at Mount Whitney Fish Hatchery in California were abandoned, due to a high incidence of furunculosis and columnaris (Toth, pers. comm.). A brood stock at Wyoming's Story Fish Hatchery had excessive mortality, due to intestinal flukes (Mitchum and Moore 1969). Fish reared in slow-growth, cold-water hatcheries have been less susceptible to harmful infections.

Genetics (Phelps 1982)

The purpose of the genetic investigation was to determine the amount and type of genetic variation that occurs in Montana golden trout, identify any evidence of introgression from other Salmo species, and determine if the observed morphological differences had a genetic basis. Findings concluded that golden trout in Montana had less genetic variation than other Salmo species and golden trout populations from California. No evidence of introgression from other Salmo was detected in any of the nine golden trout populations. There was a statistically significant gene frequency difference between golden trout populations started from sources in Montana and the Surprise Lake, Wyoming source at the only variable locus in these fish.

The amount of genetic variation found in these golden trout populations in Montana held a low average heterozygosity of 0.005. The variation was about one-third of that found in California's golden trout populations. Golden trout stocks from Cottonwood lakes has less genetic variation than the original golden trout stocks in California (Kornblatt 1973; Smith 1981). Very few adults were probably used to start the original population in the Cottonwood Lake system. However, the amount of genetic variation varied substantially between the different Cottonwood lakes, and gene frequencies of variable loci may have greatly changed since the golden trout were brought to Montana. Genetic variation apparently has been lost since golden trout were brought to Montana. Genetic variation present at Idh-3,4 in all the Cottonwood Lake samples did not occur in any of the golden trout samples from Montana.

There was no indication of hybridization with other Salmo species. No alleles characteristic of Yellowstone cutthroat trout (Salmo clarki bouveri) or westslope cutthroat trout Salmo clarki lewisi) were observed in the samples. There were no electrophoretically detectable alleles present in golden trout that distinguished them from rainbow trout. This also had been found in other studies (Allendorf and Utter 1979; Gall et al. 1976; Gold 1981; Kornblatt 1973; Smith 1981). Even though there were no diagnostic loci between golden and rainbow trout, the type and amount of genetic variation present was an indication of whether there had been any past rainbow trout introgression.

Genetic variation found in golden trout in Montana was one-tenth of that commonly found in rainbow trout populations. Many

of the commonly variable isozyme loci found in rainbow trout strains, i.e., Idh-3,4; Mdh-3,4; Pam-2, were not present in these Montana golden trout populations. It is unlikely that this low amount of genetic variation would be present if there had been introgression from rainbow trout.

Genetic variation occurred at only a single locus, Sod-1 (Table 10). The variation consisted of a fast migrating allele, Sod-1(152). This variation is common in both rainbow trout (Allendorf and Utter 1979) and golden trout (Gall et al. 1976). Aat-3,4 appeared to be variable, but inadequate resolution and lack of inheritance data prevented a confirmation of the genetic basis. There were statistically significant differences at Sod-1 between the golden trout populations started from the Surprise Lake, Wyoming source and those sources from Montana: $P < .01$, = 10.9, Idf. The golden trout populations started from the Surprise Lake stock had a low occurrence of the variant allele.

DISCUSSION

Present Status

Of the 14 lake systems in Montana with golden trout in 1981, only Lightning, Sylvan, Sawtooth, Island, Hidden #5, 6 and 7 and Golden Trout lakes appear relatively secure. Among these six populations, Lightning, Sylvan and Island had the greatest safeguards, due to their locations within a wilderness area. The Hidden lakes and Golden Trout Lake were becoming increasingly close to large timber sales. Both lake systems are influenced by easy, close access and show deteriorating shorelines and water quality. Sawtooth Lake also bordered considerable commercial-sized timber. No logging was apparent in Sawtooth basin or along Clarks Creek, its immediate drainage. Clear-cuts and roading were, however, common in the Pioneer Mountains.

The status of Cave, Shrimp and Duck lakes had not been adequately confirmed, nor had the populations been around long enough to test sustainability. Blue Danube had historic longevity and produced good yield to previous experimental netting. Its present low population status may rally; however, its future looks bleak.

Heart and Crescent lakes in the Mission Mountains will probably continue to produce erratic population densities, due in part to their reliance on recruitment from Island Lake upstream. Sylvan Lake endures; its only threat would be an unauthorized transplant of brook trout from nearby Crow Lake or an aerial stocking error.

Ranking of Lakes

A ranking of golden trout habitats (Table 11) lists Lightning lake best in Montana. Its fisheries status excels others because of its size, outlet condition, flow and nursery area 200

Table 10. Genetic variation at Sod-1 in Montana golden trout populations[1]

Lake	Genotype No. of Occurrences 100/100	100/152	152/152	Frequency of the 100 Allele
Lightning	21	7	2	0.82
Sylvan	10	9	0	0.76
Golden Trout	17	1	2	0.88
Blue Danube	0	1	0	0.50*
Hidden #5	7	0	0	1.00
Total	55	18	4	0.83
Sawtooth	29	1	0	0.98
Island	28	2	0	0.97
Fourmile Basin #4	2	0	0	1.00[1]
Hidden #2	11	0	0	1.00
Total	70	3	0	0.98

[1]From Phelps, 1982.

*Gene frequency estimates from a small number of samples may not be accurate.

Table 11. Ranking of golden trout habitats in Montana

Lakes	Access-ibility[1]	Esthetics[2]	Shoreline Abuse[3]	Water Clarity[4]	Fishery Status[5]	Spawning Area[6]
Lightning	1	1	2	1	1	1
Sylvan	3	3	3	5	2	2
Sawtooth	5	4	7	3	3	4
Island	6	5	4	6	4	3
Golden Trout	9	9	10	10	5	5
Hidden #5, 6 & 7	10	8	8	9	6	6
Cave	2	2	1	2	10	8
Fourmile Basin #4	8	10	9	8	8	9
Heart, Crescent	7	7	6	7	7	7
Blue Danube	4	6	5	4	9	10

[1]Most difficult to easiest 1-10.

Table 11. Ranking of golden trout habitats in Montana (cont.)

Lakes	Access-ibility[1]	Esthetics[2]	Shoreline Abuse[3]	Water Clarity[4]	Fishery Status[5]	Spawning Area[6]

[2]Best to worst 1-10.

[3]Least abuse to worst 1-10.

[4]Clearest to poorest 1-10.

[5]Best to worst 1-10.

[6]Best to worst 1-10.

yards downstream in Little Lightning Lake. Other high marks result from its difficult access. Even so, the lake's notoriety is spreading, accompanied by abuses that accompany fame.

Sylvan Lake is easily ranked second, followed by Sawtooth and Island lakes. Fourmile Basin Lake #4 has the best opportunity for habitat improvement and could be a viable fishery.

Angling

Golden trout are not known for catchability; however, at times they can be very vulnerable. Golden trout are much more visible and easily enticed to the bait in the shallower lake systems. Special regulations were imposed on the Cottonwood lakes, California in 1938, and fishing was closed in 1957 at Surprise Lake, Wyoming to maintain adequate densities. The only special regulations on a golden trout fishery in Montana were an August opening date for Lightning Lake to protect spawners in the outlet. The real need for this protective measure preceded wilderness classification when it was a common practice to fly nearby miners into Lightning Lake by helicopter.

Angler harvest of golden trout is best at and immediately following ice-out. Catchability becomes difficult in larger waters as fish begin feeding on larger benthic forms. Lakes such as Sylvan, Sawtooth, Hidden and Golden Trout produce catches during summer months, but to a lesser degree than would occur if the lakes were stocked with cutthroat, rainbow or brook trout. An outfitter reported an estimate of 150 fishermen per year use Sawtooth; most catch only a few fish if any (Bob NcNiel, pers., comm.).

Several waters with golden trout hybrids were excellent fisheries, producing a more catchable, highly colored fish. In some areas, e.g., Flood Creek drainage in the Beartooths, these hybrid golden x cutthroat x rainbow usually exceed sizes typical of pure strain golden trout. Requests for information on golden trout waters from fishermen are common to this investigator. Many back-country enthusiasts seek out golden trout for a rare angling experience.

Management Recommendations

The discovery that golden trout occupy so few waters in Montana and even fewer good, stable environments, makes it easy to recommend dispersement to additional waters. Because of the total absence of populations in streams, I recommend at least a couple of habitats be searched out for this purpose. I do not contend any great emphasis should be geared to goldens as a management species. Managers have an opportunity to protect, enhance and secure the golden's future in Montana. California has the obligation to secure the fishes' welfare. We in Montana can assist by taking progeny of our best original stocks and expanding their range.

Waters stocked in 1980 through 1983 require evaluation over the next few years to determine the success of those plants and the degree of self-sufficiency (Table C). Highest priority was given to systems that exhibit physical and biological characteristics comparable to the best existing golden trout habitats. The Desolation-Big Butte to Jorden Lake chain involves a six lake-stream system and has characteristics favorable to development of the best golden trout habitat in the State of Montana. The second best opportunity for a stream-lake ecosystem is the West Fishtail Creek drainage of the Beartooths.

All future proposals should consider impacts of golden trout introductions to downstream environments; generally speaking these should be minimal. I would also suggest a search of potential habitats in western Montana for improved geographic distribution. In 1984, the following golden trout plants are recommended:

Blue Danube Lake	- 4,000 fish
Hidden Lake #1	- 1,000
Hidden Lake #2	- 4,000
Hidden lakes #3, 4 and 8	- 1,000 each
Picasso Lake	- 1,500
Incisor Lake	- 1,500

Since it was apparent that many of the existing golden trout habitats were degraded physically, esthetically and biologically, some action is recommended. All existing golden trout habitats have been fisheries for years, and their historic value should be retained if at all possible.

I recommend upgrading golden trout status in the Fourmile Basin lakes #3 and 4. Lake #5 appeared to have little potential for a sustaining population. Fourmile Basin #4 has been a golden trout fishery since 1960; it was restocked in 1977. Its present low density can be attributed to the deteriorated nature of the exit of the outlet from the lake. A simple debris removal may mend the problem. It is assumed that adult spawners can return to the lake during suitable flows in the spring. Juveniles trapped in 150 feet of outlet fail to augment the lake's population.

I recommend extermination of brook trout in Fourmile Basin Lake #3 and the small, wide waters downstream. Treatment could be effective during March when access by snowmobiles could transport chemicals. Smaller amounts of chemicals are required during low oxygen levels. Recruitment from Fourmile #4 would appropriately restock Fourmile #3 slowly, allowing both food resources and golden trout establishment. In the absence of competition from brook trout, self-sufficiency should occur.

Both shorelines showed considerable abuse. I recommend a general cleanup, restrictions to camping near the shoreline and a restriction of vehicles to a distance uninfluencial to Fourmile

Basin Lake #3. An evaluation of Duck and Shrimp lakes should be undertaken. Three and 4-year-old parent stock introduced in 1977 should have had offspring of catchable size by 1982; the self-sustaining aspect looks bleak, however.

Angler dissatisfaction with the low-density fishery in Blue Danube Lake is justified. Ironically, Blue Danube supported a thriving population for years. No sign of activity leading to population failure was evident. Inadequate freshet flows necessary for cleansing substrate gravels in the outlet may be part of the problem. The existing stock has considerable historic longevity. I recommend a more detailed look at the physical habitat, food resources and population status.

Golden Trout Lake needs measures to improve the deteriorating shoreline. Camping areas have denuded large areas of vegetation and appear in part responsible for eutrophic water conditions. Camping and horse use should be discontinued near the outlet stream. The value of this historic fishery should be rated as high or higher as the associated values of the encroaching logging.

The same is true for Hidden Lake; roading and logging may cause the demise of the historic golden trout population. Since the upper lakes have been restocked with fish from Surprise Lake and have no obvious influences on Hidden lakes $5, 6 and 7, I recommend restocking lakes #1, 2, 3, 4 and 8 with either Surprise or Sylvan stock.

If goldens in Cave Lake fail to become self-sufficient, I recommend letting the lake return to a barren status. The remaining lakes in the state appear secure and/or have protective status of wilderness. I recommend these lakes be protected from introduction of other species and managers be aware of their importance and uniqueness in the State of Montana.

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Waters referred to:

Name	State Water Code
Arrowhead Lake	5-22-7174
Asteroid Lake	5-22-7187
Barrier Lake	5-22-7220
Big Butte Lake	5-22-7249
Big Park Lake	5-22-7252
Bill Lake	5-22-7266
Blue Danube Lake	3-13-6960
Blue Paradise	3-13-7020
Cairn Lake	5-22-7392
Cataract Lake	3-13-7180
Cave Lake	5-22-7449
Cimmerian Lake	5-22-7456
Cottonwood Lake #3	California
Cottonwood Lake #4	California
Crescent Lake	1-07-5880
Dewey Lake	5-22-7686
Desolation lakes	5-22-7677
Dreary Lake	5-22-7696
Dryad Lake	5-22-7698
Duck Lake	2-06-7680
Duckhead Lake	1-05-8736
Duggan Lake	5-22-7697
Emerald Lake	3-09-7980
Falls Creek Lake	5-22-8225
Fourmile Basin Lake #3	2-06-7866
Fourmile Basin Lake #4	2-06-7867
Fourmile Basin Lake #5	2-06-7868
Flood Creek lakes (6)	A series of 18 lakes including Bill, Mini, Asteroid, Pinchot, Dreary, Cimmerian, Surrender, Raven and Dryad - all listed here individually
Golden Lake	5-22-7987
Golden Trout Lake	3-09-8094
Heart Lake	1-07-6660
Herrig Lake	1-07-6700
Hidden Lake #1	3-09-8398
Hidden Lake #2	3-09-8399
Hidden Lake #3	3-09-8400
Hidden Lake #4	3-09-8401
Hidden Lake #5	3-09-8402
Hidden Lake #6	3-09-8403
Hidden Lake #7	3-09-8404
Hidden Lake #8	3-09-8405
Imagine Lake	1-05-9040
Island Lake	1-07-6880
Jasper Lake	5-22-8180
Jim lakes	1-07-6960
Jock Lake	4-20-8150

Waters referred to: (cont.)

Name	State Water Code
Kaufman (Falls Creek Lake)	5-22-8225
Lake at Falls	5-22-8330
Lake of the Isle	2-06-8256
Lake of the Winds	5-22-8344
Lake Pinchot	5-22-8890
Lake Surrender	5-22-8350
Lava Lake	3-09-8588
Lightning Lake	5-22-8372
Little Lake Creek lakes (2)	3-02-8425
Little Lake	2-06-8417
Little Lightning Lake	5-22-8372
Little Scat Lake	5-22-9097
Louise Lake (Mary Lou)	3-10-9000
Lower Dutchman Lake	3-13-7890
Lower Sky Lake	1-11-9088
Medicine Lake	5-22-8638
McKnight Lake	5-22-8612
Mini Lake	5-22-8672
Rainbow Lake	5-22-8960
Raven Lake	5-22-8972
Renshaw Lake	4-20-8000
Rhoda Lake	4-16-7920
Rimrock Lake	5-22-9002
Rock Tree Lake	5-22-9033
Sawtooth Lake	3-01-9460
Sears Lake	2-03-8925
Shrimp Lake	2-06-9180
Smith Lake Rearing Pond	1-07-8740
Snowbank Lake (Fossil)	5-22-9305
Sylvan Lake	5-22-9394
Twin Outlets Lake	5-22-9528
Upper Dutchman Lake	3-13-8860
Upper McKnight Lake	5-22-8612
Upper Sky Lake	1-11-9908
West Boulder lakes	5-22-9730
West Fishtail Creek lakes	5-22-9735